REMARKS

In the Title

The words "SILOXIRANE BASED" were removed from the title.

In the Specification

The name Siloxirane™ was capitalized and a trademark symbol added wherever it appeared in the application.

35 U.S.C. § 112 Rejections

The Examiner has rejected claims 1 thru 26 under 35 U.S.C. § 112, second paragraph, as being indefinite. Claims 1, 2, 22, 25, and 26 were rejected for indefiniteness because the claims contained the trademarked name Siloxirane™ without the appropriate capitalization, trademark symbol, and generic terminology. The appropriate capitalization and symbol have been changed or added to all occurrences of the name Siloxirane™ in the claims. The generic terminology for Siloxirane™ is best shown with a chemical diagram. Claim 22 has been changed to remove the name Siloxirane™ from the claim and to show an epoxy resin as an element of the claim comprising the chemical composition illustrated in a diagram. Applicant submits that Claim 22 is definite for describing the epoxy resin and, accordingly, the identification/description of the name Siloxirane™ is also definite in claims 1, 2, 25, and 26. Applicant further submits that claims 3-21, 23, and 24 should also be allowed because they depend on 1, 2, 22, 25, and 26.

The Examiner has rejected claims 4, 7, 8, 12, and 17 for being indefinite because the claims contained confusing language. The language of each claim has been amended to clarify the meaning of the claim. In claim 8, a missing hydrogen atom was added to the chemical diagram. Applicant submits that claims 4, 7, 8, 12, and 17 should be allowed.

Applicant respectfully requests withdrawal of the rejections of claims 1 thru 26 under 35 U.S.C. § 112, second paragraph, as being indefinite.

35 U.S.C. § 103 Rejections

The Examiner has rejected claims 1 thru 26 under 35 U.S.C. § 103(a) as being unpatentable over Wong in view of Keehan. The Examiner believes that it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the no-flow epoxy underfill material disclosed by Wong by providing for a Siloxirane™ epoxy to obtain multiple advantages.

Applicant believes that modifying the underfill material by using Siloxirane™ was not obvious to one of ordinary skill in the art at the time the invention was made. Applicant respectfully mentions to the Examiner that Applicant is named as a co-inventor of the no-flow underfill material claimed in Wong. As the co-inventor, Applicant was intimately familiar with the art of the Wong patent. Because of Applicant's experience with the Wong patent, Applicant possessed extraordinary skill of the art of no-flow materials at the time that the invention was made.

The metallic oxide-oxirane pre-polymer disclosed in Keehan was not considered as a component of the no-flow formulation in Wong because the benefits of applying

Siloxirane™ as part of a no-flow material application were not realized by Applicant at the time that Applicant co-invented that invention claimed in Wong. If the advantages of using Siloxirane™ in a no-flow underfill material were not known to Applicant, someone of extraordinary skill in the art of no-flow underfill materials, this knowledge would not have been obvious to someone of ordinary skill in the art.

Wong teaches that the epoxy resin used in the no-flow underfill process is a pure organic epoxy resin. The Siloxirane™ epoxy resin taught in Keehan, however, is basically an inorganic/organic resin. The coefficient of thermal expansion (CTE) of the cured organic epoxy resin taught in Wong (60-80 ppm/c) is much higher than the CTE of the inorganic/organic Siloxirane™ epoxy resin taught in Keehan, which is adjustable between 20 ppm/c and 50 ppm/c. For the inorganic/organic Siloxirane™ epoxy resin in Keehan, no added silica filler is needed, as taught in Wong, to reduce the CTE of the cured organic epoxy resin. Keehan does not teach that the CTE of the inorganic/ organic Siloxirane™ epoxy resin is in a CTE range desirable for use as a no-flow underfill material.

No-flow underfill materials preferably have unique properties to meet applications requirements such as fluxing capacity, low CTE, and unique curing kinetics. A person skilled in the art of Siloxirane™ manufacture does not know how to properly use Siloxirane™ with other components such as flux to be a desirable no-flow material. The person skilled in the art of microelectronic flip chip packaging does not know that the chemical structure of Siloxirane™ can provide the desired CTE value for their applications. Modifying the no-flow epoxy underfill material disclosed in Wong by

providing for a Siloxirane™ epoxy resin disclosed in Keehan would not have been obvious to one of ordinary skill in either art.

Applicant, accordingly, respectfully requests withdrawal of the rejections of claims 1 thru 26 under 35 U.S.C. § 103(a) as being unpatentable over Wong in view of Keehan.

Applicant respectfully submits that the present application is in condition for allowance. If the Examiner believes a telephone conference would expedite or assist in the allowance of the present application, the Examiner is invited to call Stephen M. De Klerk at (408) 720-8300.

Please charge any shortages and credit any overages to Deposit Account No. 02-2666. Any necessary extension of time for response not already requested is hereby requested. Please charge any corresponding fee to Deposit Account No. 02-2666.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Date: August 13, 2002

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VERSION OF AMENDED TITLE, SPECIFICATION, AND CLAIMS WITH MARKINGS TO SHOW CHANGES

In the Title

[SILOXIRANE BASED] NO-FLOW UNDERFILL MATERIAL

In the Specification

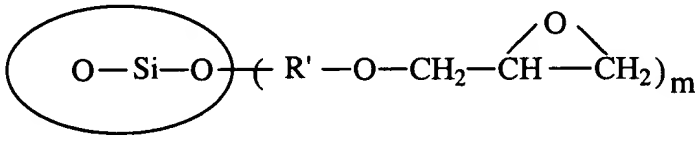
[0010] A no-flow underfill material is provided that includes at least:

(i) an epoxy [siloxirane] Siloxirane™ resin,

(ii) at least one agent acting as a cross-linking hardener capable of curing an epoxy resin and a curing catalyst capable of catalyzing the curing of the epoxy resin, and

(iii) a compatible fluxing agent.

[0011] The [siloxirane] Siloxirane™ resin may in its pre-cure monomer state be represented by:



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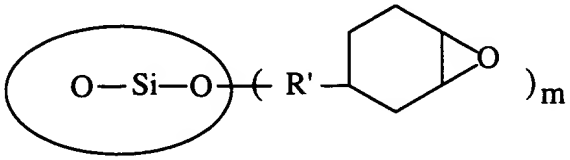


(2)

where m is the number of reactive oxirane groups on the surface of the O-Si-O domain

and m ranges from 1 to 30. R′ is selected from the group consisting of phenylene, bisphenylene, carbonyl, and alkylene. The alkylene herein refers to a branched or unbranched saturated hydrocarbon group of 1 to 24 carbon atoms, such as methylene ("Me"), ethylene ("Et"), *n*-propylene, isopropylene, *n*-butylene, isobutylene, *t*-butylene, octylene, decylene, and the like. Preferred alkylene groups herein contain from 1 to 12 carbon atoms. An organic moiety may be used in the monomer in eq. 1 to link the SiO_2 group with the oxirane group.

[0015] The agent acting as a cross-linking hardener and a catalyst may be a single material such as an imidazole or its derivative, triphenylphosphine, or an onium salt. The agent may include a separate hardener and catalyst. The hardener may for example be an amine, an anhydride, a poly amide, a polyamide amine, or a phenolic resin and the catalyst may be an imidazolium salt, or a tertiary amine. The agent, during curing, creates a polymerized polymer out of the monomer with a three-dimensional cross-linked structure. The ratio at which the imidazole or its derivatives, or tripheylphosphine, or onium salt that is added in the formulation ranges from 0.01wt% to 20wt% of the weight of the [siloxirane] Siloxirane™ resin. The ratio at which amine, or polyamide, or polyamide amine that is added in the formulation is 1 reactive amine hydrogen equivalent to 0.1 to 10 epoxide equivalent of the [siloxirane] Siloxirane™ resin. The ratio at which anhydride that is added in the formulation is 1 anhydride ring equivalent to 0.1 to 10 epoxide equivalent weight of the [siloxirane] Siloxirane™ resin.

[0016] The fluxing agent can be any acid which can be dissolved in the [siloxirane] Siloxirane™ resin and the agent. The fluxing agent is preferably an organic carboxylic acid, or a polymeric fluxing agent, or an organic compound that contains one or more hydroxyl groups. The fluxing agent may for example be a glutaric acid or a trifluro acetic acid. The ratio at which a fluxing agent that is added in the formulation ranges from 0.1wt% to 20wt% of the weight of the [siloxirane] Siloxirane™ resin.

[0017] The material preferably further includes an adhesion promoter to further increase the adhesion strength between underfill material [to] and all contact surfaces. The adhesion promoter may for example be a silane coupling agent, an organo-ziconate, or an organo-titanate. The ratio at which an adhesion promoter is added in the formulation ranges from 0.01wt% to 10wt% of the weight of the [siloxirane] Siloxirane™ resin.

[0018] The material preferably further [including] includes a non-ionic surfactant to help material flow and eliminate process voids. The surfactant may be a polyol, a siloxane compound, [and] or a fluorinated compound such as FC-430 from 3M Corporation of St. Paul, Minnesota. The ratio at which an adhesion promoter is added in the formulation ranges from 0.01wt% to 10wt% of the weight of the [siloxirane] Siloxirane™ resin.

[0019] The material preferably further includes a de-foaming agent which prevents air entry and bubble formation during processing. The de-foaming agent may for example be BYK-066 from BYK-chemie of Wesel in Germany. The ratio at which a de-foaming agent is added in the formulation ranges from 0.01wt% to 10wt% of the weight of the [siloxirane] Siloxirane™ resin.

[0020] The material preferably further includes fused silica to further reduce CTE and moisture uptake, and increase modulus. The ratio at which a fused silica is added in the formulation ranges from 1wt% to 300wt% of the weight of the [siloxirane] Siloxirane™ resin.

[0021] The material preferably further includes silver flakes to provide electrical conductivity. The ratio at which a silver flake is added in the formulation ranges from 10wt% to 500wt% of the weight of the [siloxirane] Siloxirane™ resin.

[0022] The material preferably further includes thermally conductive particles to provide desired thermal conductivity. The thermally conductive particles may for example be silicon nitride, silicon borate, alumina, diamond, or silicon oxide. The ratio at which a thermally conductive [particles] particle is added in the formulation ranges from 10wt% to 500wt% of the weight of the [siloxirane] Siloxirane™ resin.

Example 1

a. [Siloxirane] Siloxirane™ resin (eq. 1 or 2):	100 part (by weight)
b. 2-ethyl-4-methyl imidazole acting as both hardener and catalyst:	4 parts
c. Glutaric acid as a fluxing agent:	4.0 part
d. FC-430 as a surfactant:	0.2 part
e. BYK-066 (defoaming agent):	0.05 part
f. 3-glycidoxy propyl methyl diisopropenoxy silane (adhesion promoter)	0.2 part
g. fused silica filler	40 parts

Example 2

a. [Siloxirane] Siloxirane™ resin (eq. 1 or 2):	100 part (by weight)
b. methyl hexahydrophthalic anhydride acting as a hardener:	100 parts
c. triphenylphospine acting as a catalyst:	0.8 parts
d. Glutaric acid as a fluxing agent:	8.0 part
e. glycerol (assisting fluxing agent)	8.0 parts
f. polyoxyethylene (surfactant):	0.4 part
g. BYK-066:	0.1 part
h. neopentyl (diallyl)oxy tri(N-ethylenediamineo) ethyl titanate (adhesion promoter)	0.6 part
i. silicon nitride (thermally conductive particles)	100 parts

Example 3

a. [Siloxirane] Siloxirane™ resin (eq. 1 or 2):	100 part (by weight)
b 2-phenyl-4,5-dihydroxymethylimidazole:	6 parts
c. trifluoro acetic acid as a fluxing agent:	4.0 part
d. silicone as a surfactant:	0.4 part
e. BYK-066:	0.05 part
f. neopentyl(diallyl)oxy tri(dioctyl) pyrophosphato zirconate (adhesion promoter)	0.3 part
g. silver flakes (electrically conductive filler)	300 parts

In the Claims

Claims 27 and 28 are new.

1. (Amended) A no-flow underfill material comprising:

an epoxy [siloxirane] Siloxirane™ based resin;

at least one agent acting as a cross-linking hardener and a curing catalyst capable of catalyzing the curing of the epoxy resin; and

a fluxing agent.

2. (Amended) The material of claim 1 wherein the [siloxirane] Siloxirane™ based resin is represented by:

R1 — R3 — R2

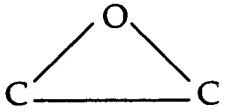
where R1 includes SiO_2

R2 is a reactive organic functional group, and

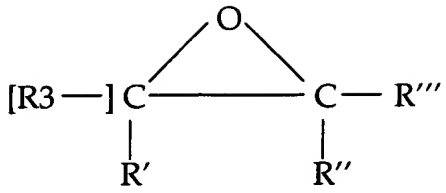
R3 is an organic chain segment.

4. (Amended) The material of claim 3 wherein a structure of R1 is a [cylic] cyclic SiO_2 domain.

6. (Amended) The material of claim 2 wherein R2 includes [the] an oxirane group represented by:

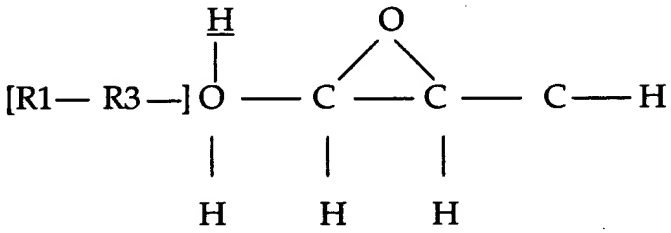


7. (Amended) The material of claim 6 wherein R2 [and R3 are] is represented by:



Wherein R′, R″, and R‴ are hydrogen or alkyl groups.

8. (Amended) The material of claim 7 wherein [R1,] R2 [and R3 are] is represented by:



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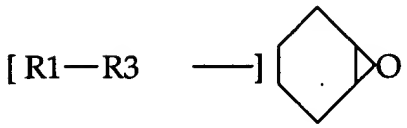


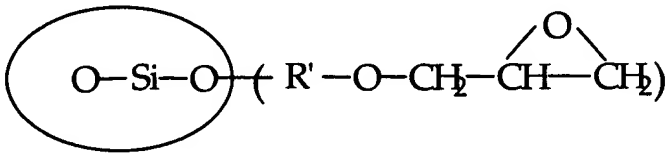
10. (Amended) The material of claim 1 wherein the cross-linking hardener is selected [form] from the group consisting of an imidazole and its derivatives, an amine, a triphenylphosphine, an anhydride, a polyamide, a polyamide amine, a phenolic resin, and an onium salt.

12. (Amended) The material of claim 1 wherein the fluxing agent is dissolved in a mixture of the epoxy Siloxirane™ based resin and the agent acting as a cross-linking hardener.

17. (Amended) The material of claim 16 wherein the surfactant is selected from the group consisting of polyol, a siloxane compound, and a fluorinated compound.

22. (Amended) A no-flow underfill material comprising:

an epoxy [siloxirane] resin represented by



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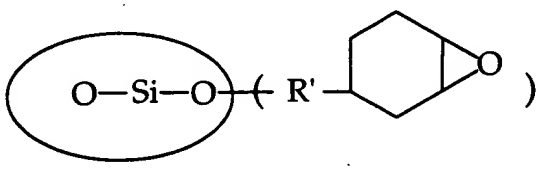


(2);

at least one agent acting as a cross-linking hardener and a curing catalyst capable of catalyzing the curing of the epoxy resin; and

a fluxing agent.

23. (Amended) The no-flow underfill material of claim 22 further comprising:

an adhesion promoter;

a non-ionic surfactant;

fused silica;

silver flakes; and

thermally conductive particles.

25. (Amended) A semiconductor package comprising:

a package substrate;

bond pads on the substrate;

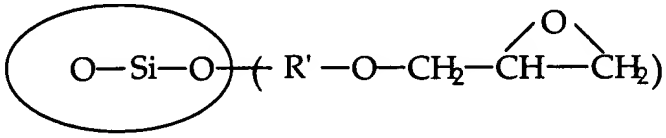
a semiconductor die;

contact pads on the semiconductor die;

a respective conductive bump on each contact pad, the die being located so that each bump is in contact and attached to a respective bond pad; and

an underfill material filling regions between the bumps and including at least an epoxy [siloxirane] Siloxirane™ based resin.

26. (Amended) The semiconductor package of claim 25 wherein the epoxy [siloxirane] Siloxirane™ based resin is represented by:



or